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Investigation of effect of conical flat tool feature variation on Fatigue load carrying capacity of Friction Stir Welded AA 6XXX plate

"Investigation of effect of conical tool feature variation on Friction Stir Welded AA 6351 plate"

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***Abstract* – Friction stir welding (FSW) is an innovative solid state joining process, developed by The Welding Institute, UK for joining aluminum, magnesium, zinc and copper alloys. FSW is being used in aerospace, automotive, rail, marine industries, fabrication, etc. FSW is more beneficial over traditional welding process, particularly in the areas of weld quality and environmental impacts. The FSW process parameters such as tool rotation and transverse speed, tool design, axial force, play a major role in deciding the weld quality. In this article, we are going to analyze joining of two same materials by varying affecting parameters and to carry out the optimized set of parameters, which will give high strength for particular pair of dissimilar materials. An attempt has been made to join aluminum alloy 6351 T6 plate having dimension of 120*50*12 with three different featured conical tool friction stir welding (FSW). FSW is more eco-friendly and refine process which give higher joint efficiency than fusion welding process if proper parametric is used. Process parameter like Rotational speed, welding speed, Fixture design, Tool Design, Tool Pin are studied in this research work. Welding speed or transverse speed, Range of RPM and tool features are chosen for Experimental work. Check the fatigue test on different range, speed and conical tool using the welding process and check the fatigue life of weld specimen.**

***Index Terms* – FSW, Conical flat tool, Fatigue properties**

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1. INTRODUCTION

Friction stir welding (FSW) is an innovative solid state joining process, developed by The Welding Institute, UK in 1991. FSW is being used in aerospace, automotive, rail, marine industries, fabrication, etc. FSW is more beneficial over traditional welding process, particularly in the areas of weld quality and environmental impacts. The FSW process parameters such as tool rotation and transverse speed, tool tilt and plunge depth, tool design, axial force, play a major role in deciding the weld quality. Among aluminium alloys, aluminium-magnesium-silicon (Al-Mg-Si) heat treatable alloys, although of only medium strength, appears to have weld ability advantage over high strength aluminium alloys. For this reason Al-Mg-Si alloys are widely used for structural components in welded assemblies. FSW may produce high tensile stresses elsewhere in the components, FSW results in a much lower distortion and residual stresses owing to the low heat input characteristics of the process.

So far we have examined materials behaviour under slowly rising load (the tensile test) and under impact loading (the impact test). We learned from the first test that a smooth specimen fails by overloading if the statistically applied stress exceeds the tensile strength of the material. However, failure can still occur at a stress level less than the yield strength (σy) if the applied stress is fluctuating with time. Failure caused by cyclic loading is termed fatigue and the number of total loading cycles applied until fracture is called the fatigue-life. The majority of engineering components experience some sort of load fluctuations and it has been estimated that fatigue is responsible for more than 70% of all engineering materials failures. Therefore, engineers should be aware of this type of failure and know how to design against it.

2. MATERIAL SELECTION

FSW is applicable to following Aluminium Alloys:

- Aluminium 2xxx Alloys (AA2013, AA 2014, AA2024, AA 2219)etc.
- Aluminium 5xxx Alloys (AA 5093)
- Aluminium 6xxx Alloys (AA 6013, AA 6061, AA 6063 , AA 6351)
- Aluminium 7xxx Alloys (AA 7010, **AA 7050**, AA 7075, AA 7475) etc.

Aluminium AA 6351

Aluminum alloy 6351 is a medium strength alloy with excellent corrosion resistance. It has the highest strength of the 6000 series alloys. Alloy 6351 is known as a structural alloy. In plate form, Aluminum alloy 6351 is the alloy most commonly used for machining.

As a relatively new alloy, the higher strength of Aluminum alloy 6082 has seen it replace 6082 in many applications. The addition of a large amount of manganese controls the grain structure which in turn results in a stronger alloy.

In the T6 temper, Aluminium Alloy 6351 machines well and produces tight coils of swarf when chip break.

Table 2.1 Aluminium Material Composition

Al	Si	Fe	Mn	Mg	Cr	Zn	Ti	V	Other
99	0.25	0.35	0.03	0.03	0.05	0.05	0.03	0.05	0.03

3. PROCESS PARAMETER

After studying different process parameters affecting the process of FSW, we have taken following input parameters for my project work.

1. Tool Rotational Speed
2. Tool Feed
3. Conical Tool Feature

Table 3.1 Tool Material Mechanical Properties

Tensile Strength Ultimate MPa	Yield Stress MPa	Hardness HB
850-1000	1000-1380	248-302

Threads and flutes on the pin are to increase heat generation rate due to larger interfacial area, improve material flow and affect the axial and transverse force.

Three different conical tools are use

1. Conical Flat tool

Figure 3.1 Conical Flat Tool

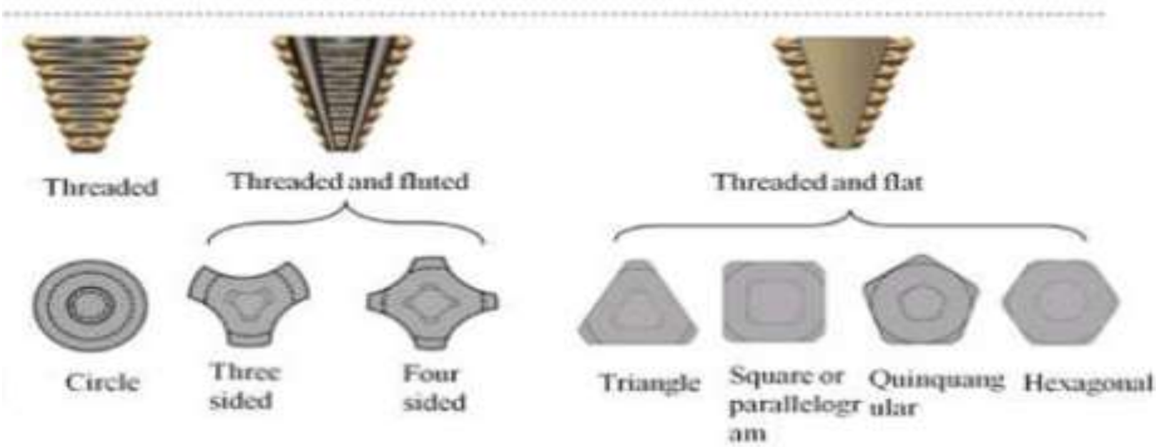

Figure 3.4 Conical Flat tool

Why conical tool is select?

1. Low transverse force compared to cylindrical tool.
2. Increased plastic strain and temperature in nugget join.
3. Strength of conical tool is high.
4. Conical tool reduce the process force. (Particularly the vertical)

5. Tool tilt angle is zero or neglected in the conical tool.

4. EXPERIMENTAL SETUP

As shown in figure the fixture is fitted on the milling machine bed. On which plates are fitted between the fixture and from the back side backup plates are there for giving the support against the force. The tool is mounted on the milling machine head.

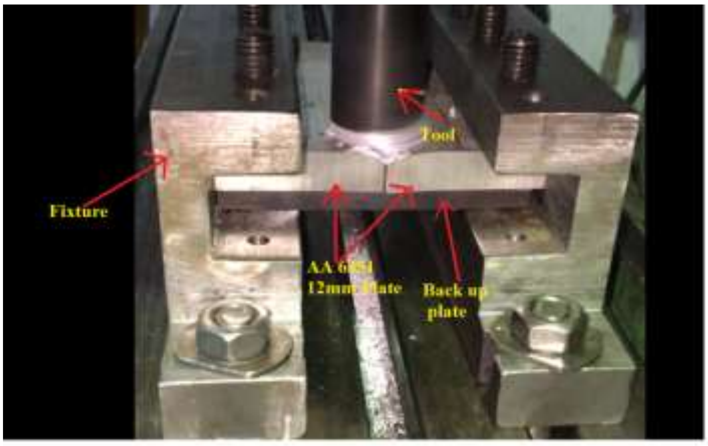

Figure 4.1 Experimental setup

Based on full factorial method in which total 9 experiment are done .Three different speed and feed and also three different tool feature are use in the this welding process. By macro examination in all this joints fluted tool joints strength and fatigue life is more come pare to other weld joints because of some weld joints crack and surface is not clean so in fluted tool no crack are there.

It has been recognized that a metal subjected to a repetitive or fluctuating stress will fail at a stress much higher than that required to cause failure on a single application of load. Failures occurring under conditions of dynamic loading are called fatigue failures.

Table 4.1 Fatigue cycle table for flat tool specimen

Flat Tool Cyclic load = 8 KN				
Sr. No.	Speed (RPM)	Feed (mm/m)	No of Cycle	Designated Specimen No:
1	A	X	8139	2
2	A	Y	9447	18
3	A	Z	9258	17
4	B	X	5143	1
5	B	Y	5433	3
6	B	Z	5361	4
7	C	X	4850	6
8	C	Y	1	5
09	C	Z	3955	16

Table 4.1 represents no of fatigue load cycles weld can carry as per its weld quality and weld strength with base load of 8 KN. The maximum no of stress cycles a feature less conical tool can carry is 9447 cycles with 8KN of base load.

5. ANALYSIS AND RESULTS

So, after getting that result for the various tools. After getting that value from the experimental results, that value put in to the Minitab for finding variation in the result because of process parameter variation. We are getting the different plots for different values. Here given below is the graphical representation for the results. Here, given below graphical representation is for FLAT Tool.

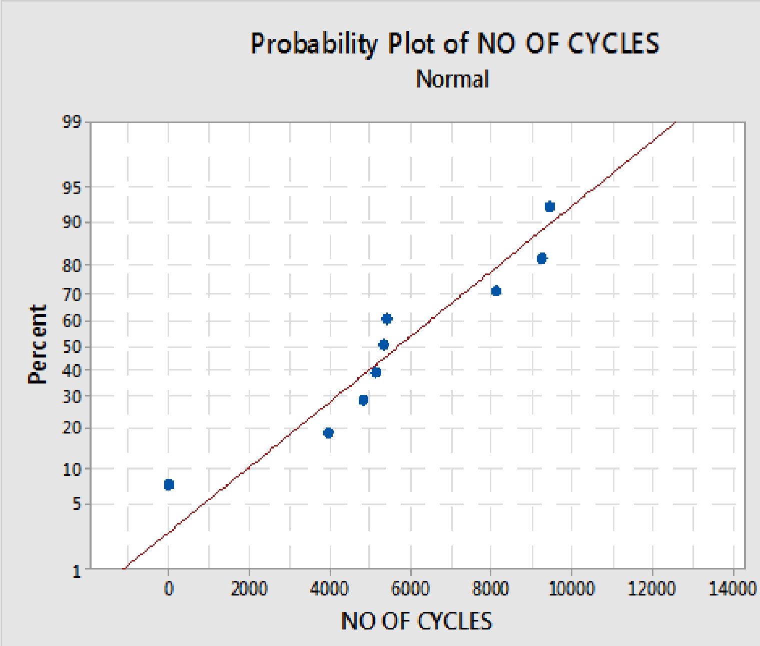

Figure 5.1 Probability Plot of No of cycles for Flat tool

The plot suggests that as per the confidence interval available the values are normally distributed along the mean variance line. The percentage increases when the no of cycles are increases.

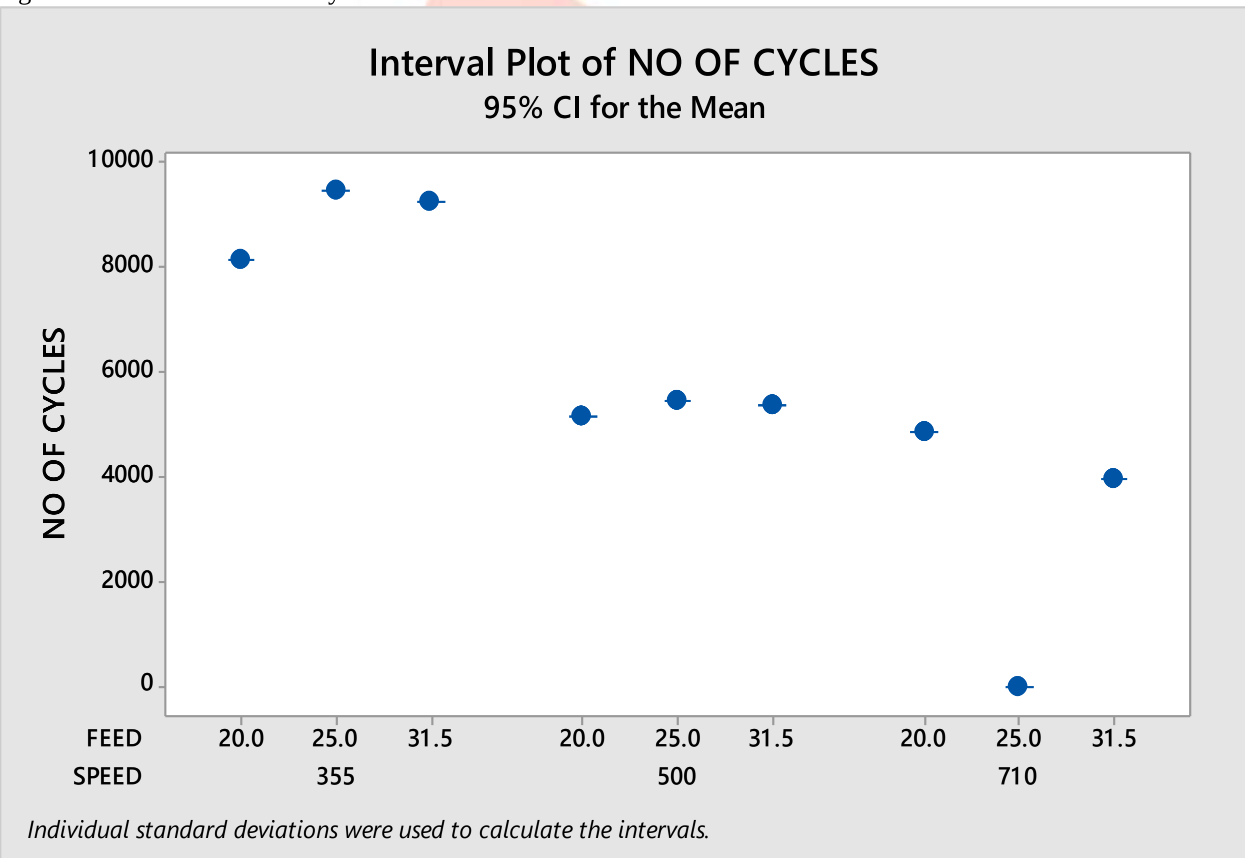

Figure 5.2: Interval plots for No of cycles for Flat tool

Figure 5.2 represents the interval plots for the variation in no. of load cycles with base load, when the speed and the feed are varying till failure of the specimen. At the speed of 355 RPM and feed of 25 mm/minute the no of cycle are more, which suggests that weld plates are able to with stand more cyclic loadings about 10000 for the specific loading condition. At the speed of 710 RPM and 25 mm/minute the no of cycles having less no of cycles ,which suggests that the the weld plates are not able to with stand its strength above approximately 5500 no. of cycles.

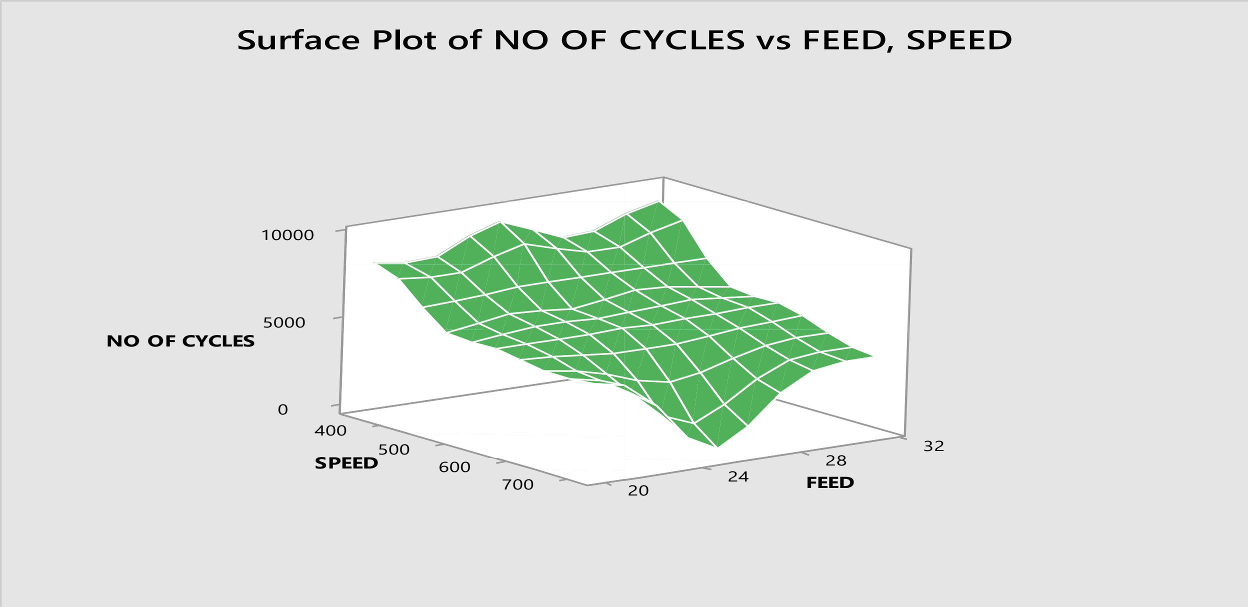

Figure5.3 Surface Plot of No of cycles vs Feed and Speed for Flat tool

Figure 5.3 shows surface plot for the response (No. Of load cycles carried by weld plate) available from experimental trials. It suggests that the response is gradually decreasing with increase in speed and it is having merged affect when defines feed change.10mesh size is presented to make the plot observable.

6. CONCLUSION

As we shown presentation and laboratory data, we found that for the flat tool at the speed of 355RPM and feed of 25 mm/minute take 9447 cycle to break specimen at 8kg load. And for threaded tool at the speed of 355RPM and feed of 20 mm/minute take 6039 cycle to break specimen at 26kg load and for the last, In fluted tool 5213 cycle to brake the specimen is at speed of 710RPM and feed of 20 mm/minute at 65kg load. So, we also conclude that the fluted tool gives the optimum value because as we shown the best optimum results for individual tool, in fluted tool maximum load is given compare to other and in that tool it's take more cycles compare to others. So we can say that fluted tool give better results compare to other tools in this case of study.

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